

Raytheon BBN Technologies

SpaDE
Space Debris Elimination

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SpaDE... |

Space Debris Elimination



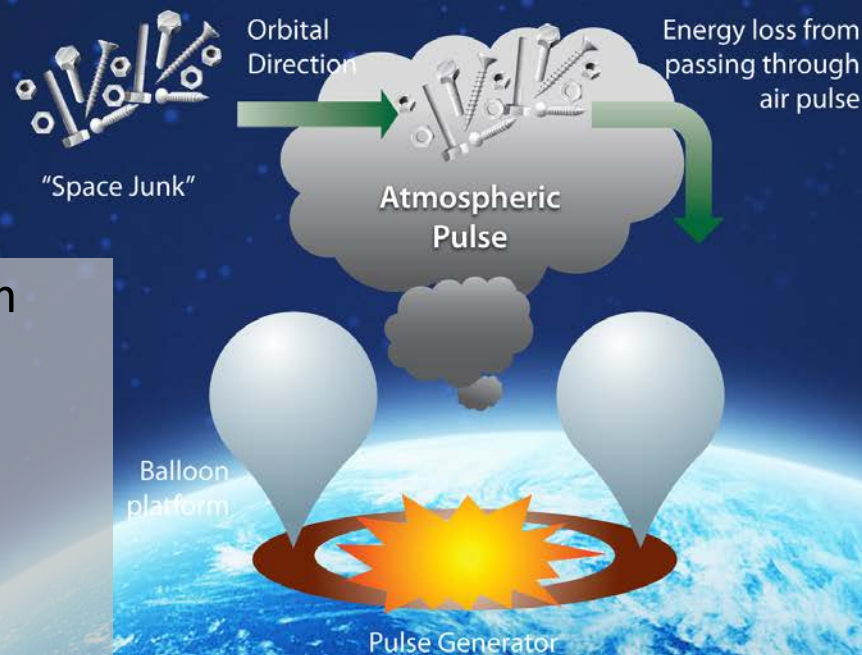
NIAC Symposium 2012

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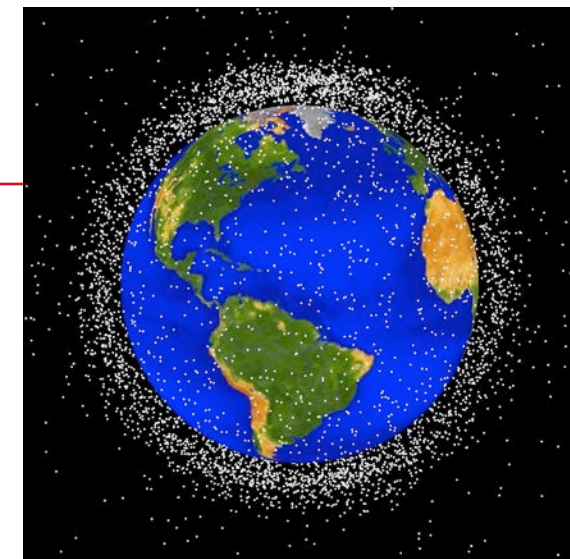
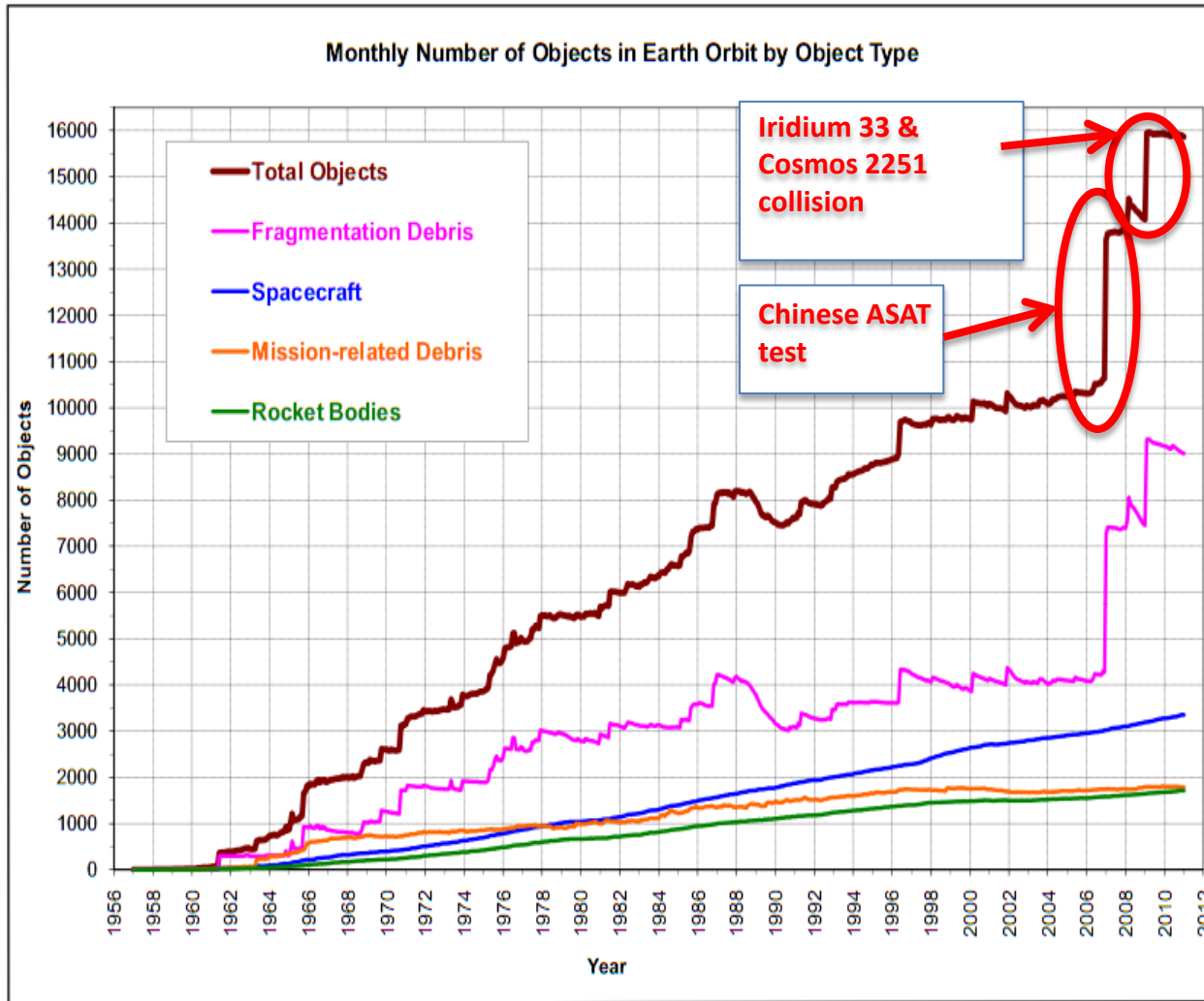
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Agenda

- Space Debris Problem
- SpaDE Concept
- Research Questions
- NIAC Study
 - Status
 - Preliminary Results
 - Intermediate Conclusion
- Further Studies



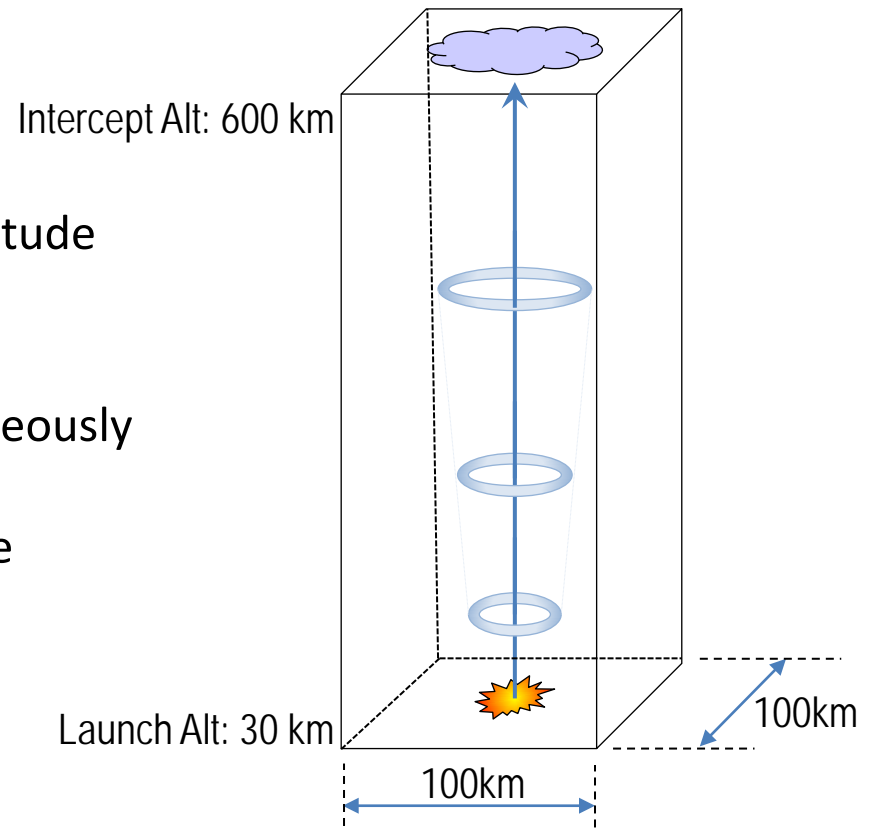
The Space Debris Problem



- The amount of space debris is rising rapidly, jeopardizing the safety of our satellites and spacecraft
- Space debris removal is one of the space operations main objectives
- No viable solutions have been created

SpaDE

- Concept to accelerate atmospheric drag effect on targeted debris fields.
- Advantages
 - Launch altitude
 - Economical to transport mass to altitude
 - Above 99% of atmosphere
 - Interception Altitude
 - Can affect multiple objects simultaneously
 - Not lofting more potential debris
 - All air falls back into the atmosphere
- Modalities
 - Explosive
 - Air Cannons



Key Research Questions

- ***Viabile:***

Do the fundamental dynamics in the upper atmosphere support the SpaDE approach?

- ***Economical:***

What is the most cost-effective modality that produces the desired effect?

- ***Effective:***

– How does the perturbation affect the dynamics of the debris?

- ***Useful:***

– What is the extent of the SpaDE effect?

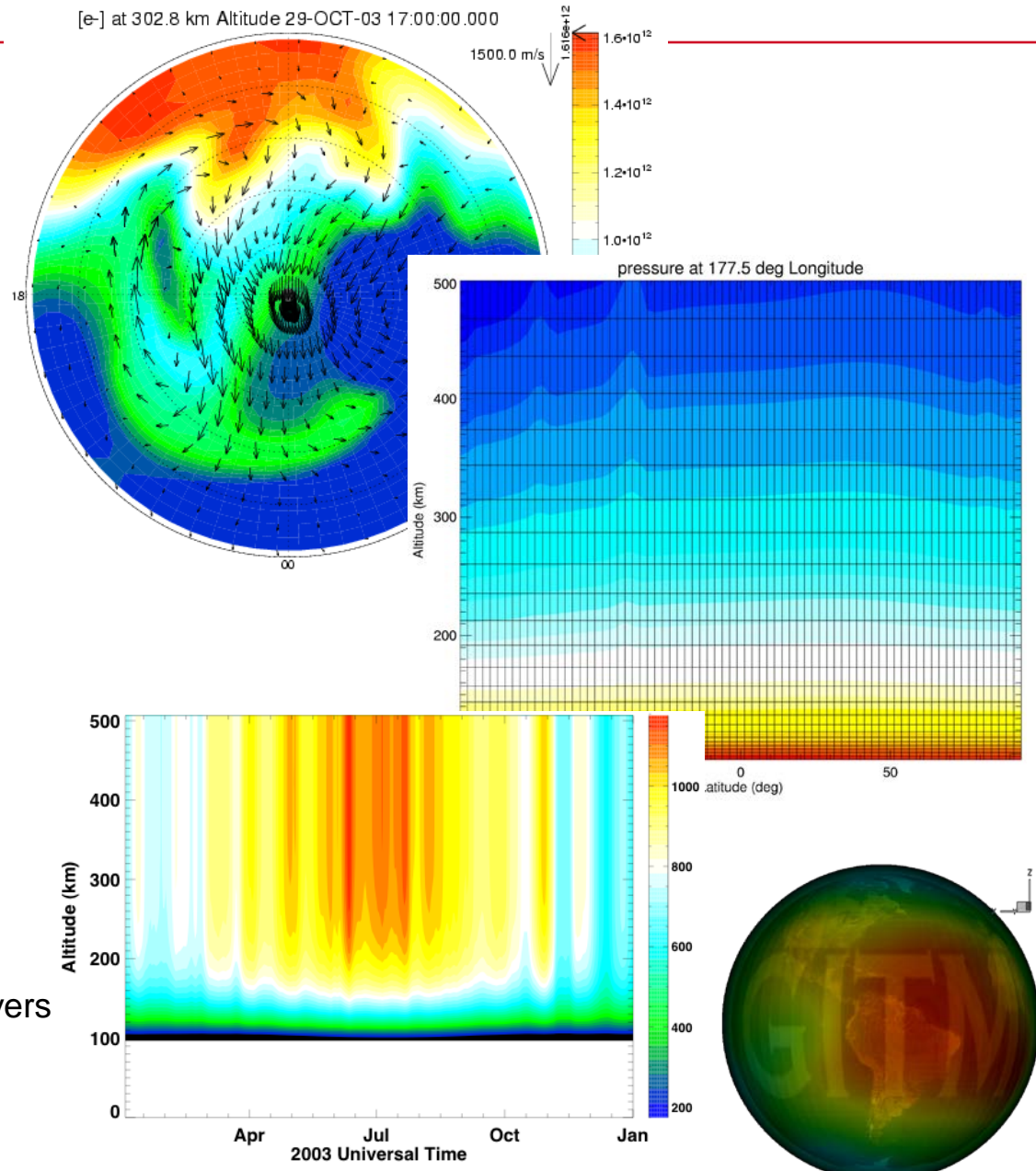
NIAC Study

- Assessing the viability of the SpaDE concept.
- Modeling upper atmosphere affects relevant to the operation of SpaDE
 - Extending Global Ionosphere Thermosphere Model (GITM)
- Analyzing the effects and impacts of the perturbations on space debris

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- ✓ 6 Neutral & 5 Ion Species
- ✓ Neutral winds
- ✓ Ion and Electron Velocities
- ✓ Neutral, Ion and Electron Temperatures

- ✓ Solves in Altitude coordinates
- ✓ Can have **non-hydrostatic** solution
 - ✓ Coriolis
 - ✓ Vertical Ion Drag
 - ✓ Non-constant Gravity
 - ✓ Massive heating in auroral zone
 - ✓ **Significant energy perturbations**
- ✓ Runs in 1D and 3D
 - ✓ 3D Global
 - ✓ **3D Regional (for NIAC work)**
- ✓ Vertical winds for each major species with friction coefficients
- ✓ Non-steady state explicit chemistry
- ✓ Flexible grid resolution - fully parallel
- ✓ Variety of high-latitude and Solar EUV drivers
- ✓ Fly satellites through model

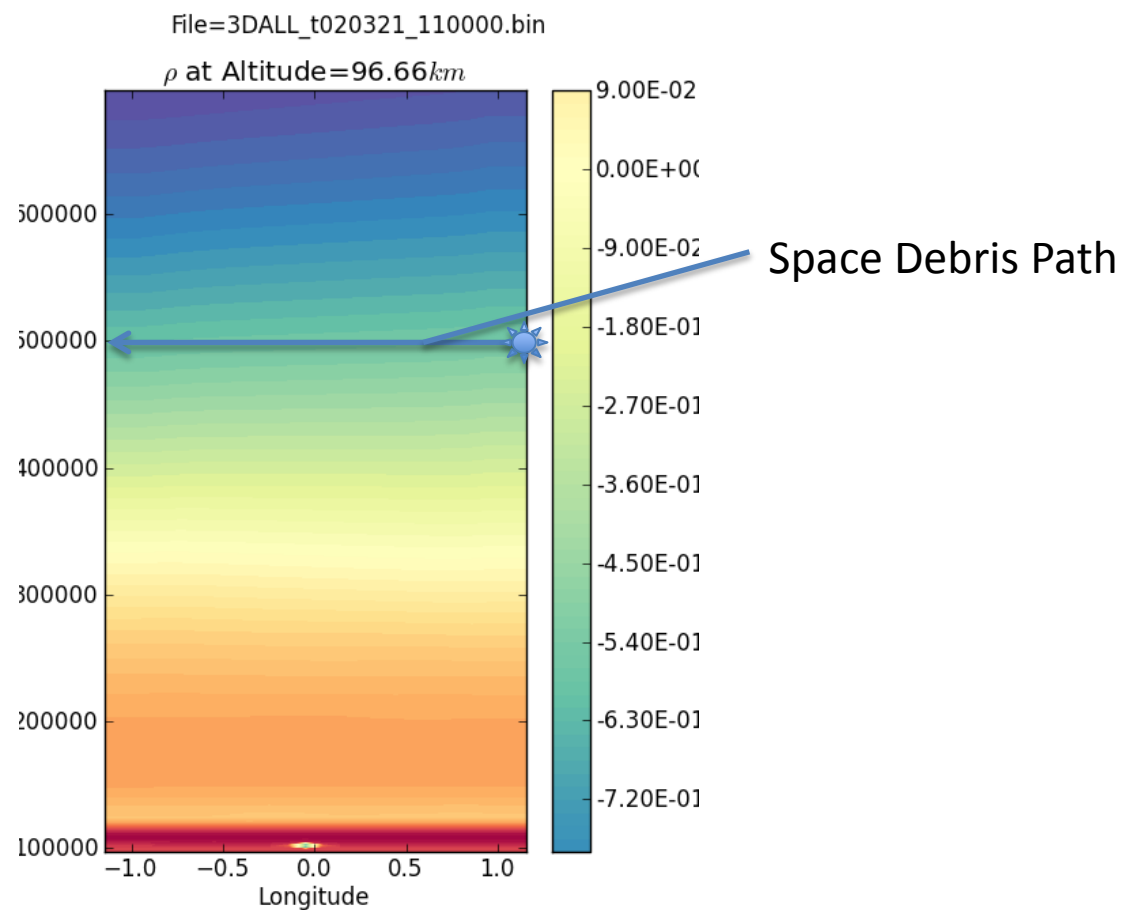


Status

- Current
 - GITM Model Updates
 - Created “box model” to allow the model to run in a localized region
 - Used perturbations in the model to simulate explosive reactions
 - Can create perturbations in temperature, density and winds
 - Added dynamic perturbations
 - Perturbations can happen over any amount of time
 - Reduced the lower bound of the model from 100km to 80km
 - Initial perturbation runs
 - Shows that atmosphere does affect LOE
 - In the process of assessing the results

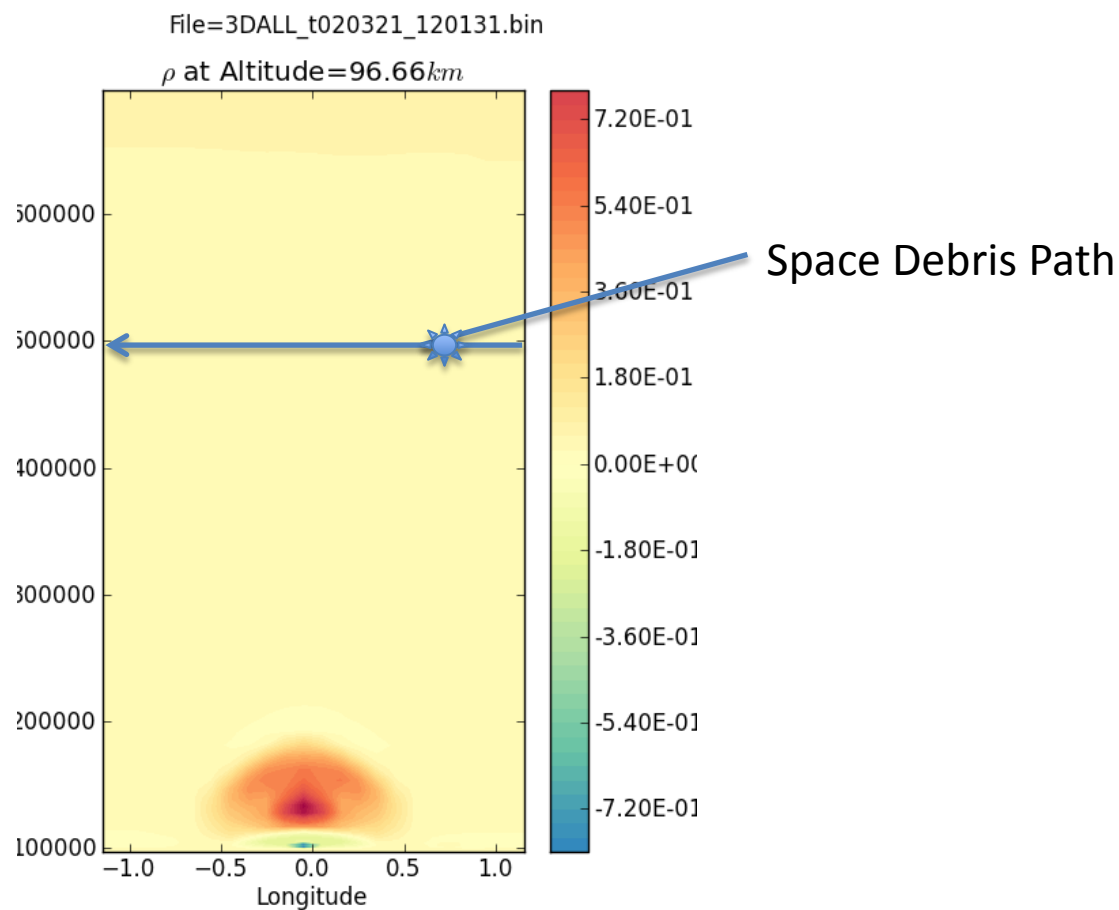
Perturbation Run 1

Disclaimer: color not consistent
space debris not accurate



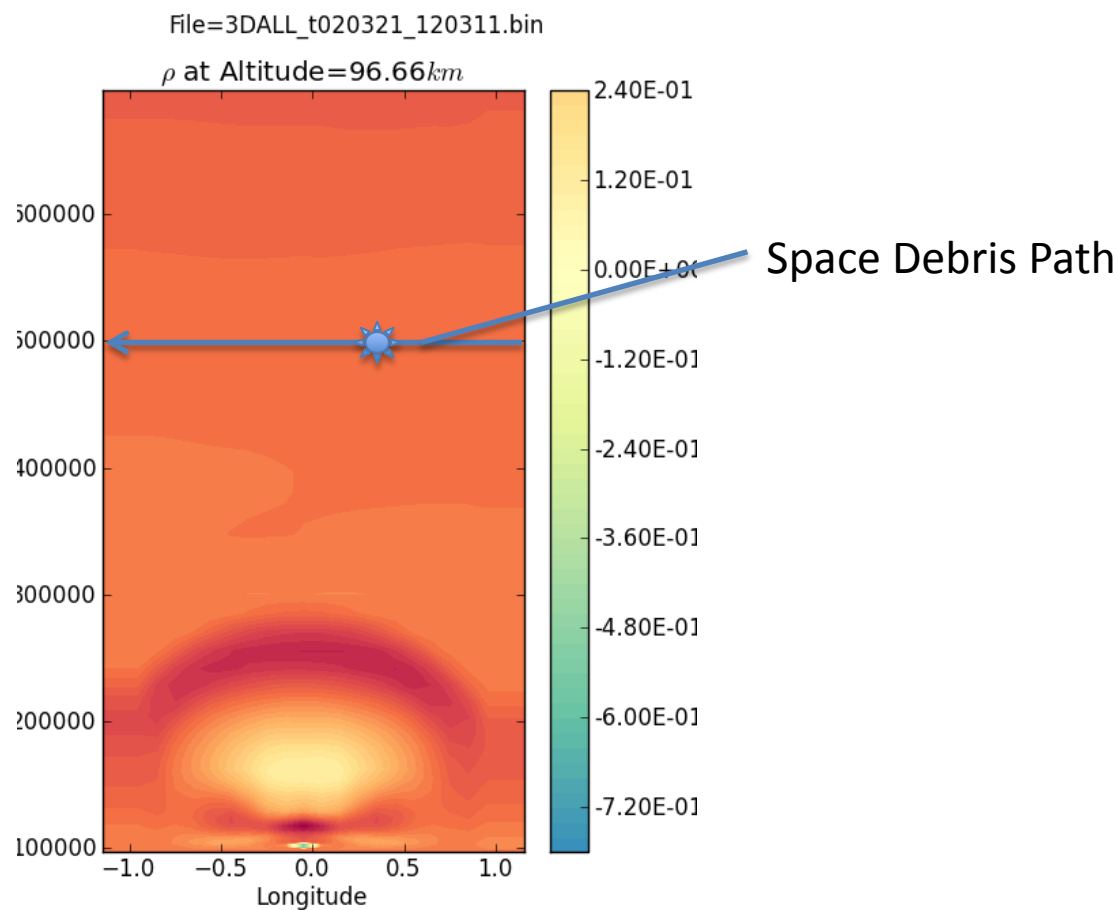
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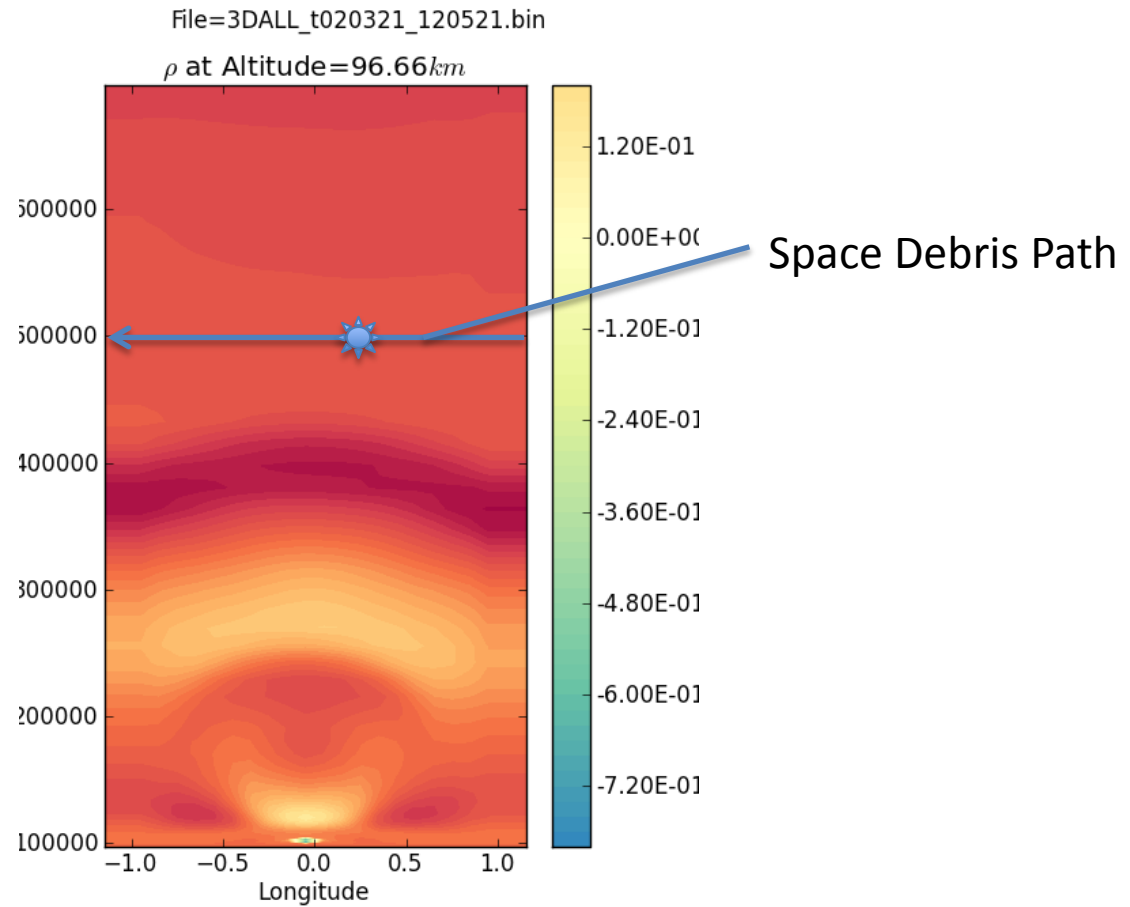
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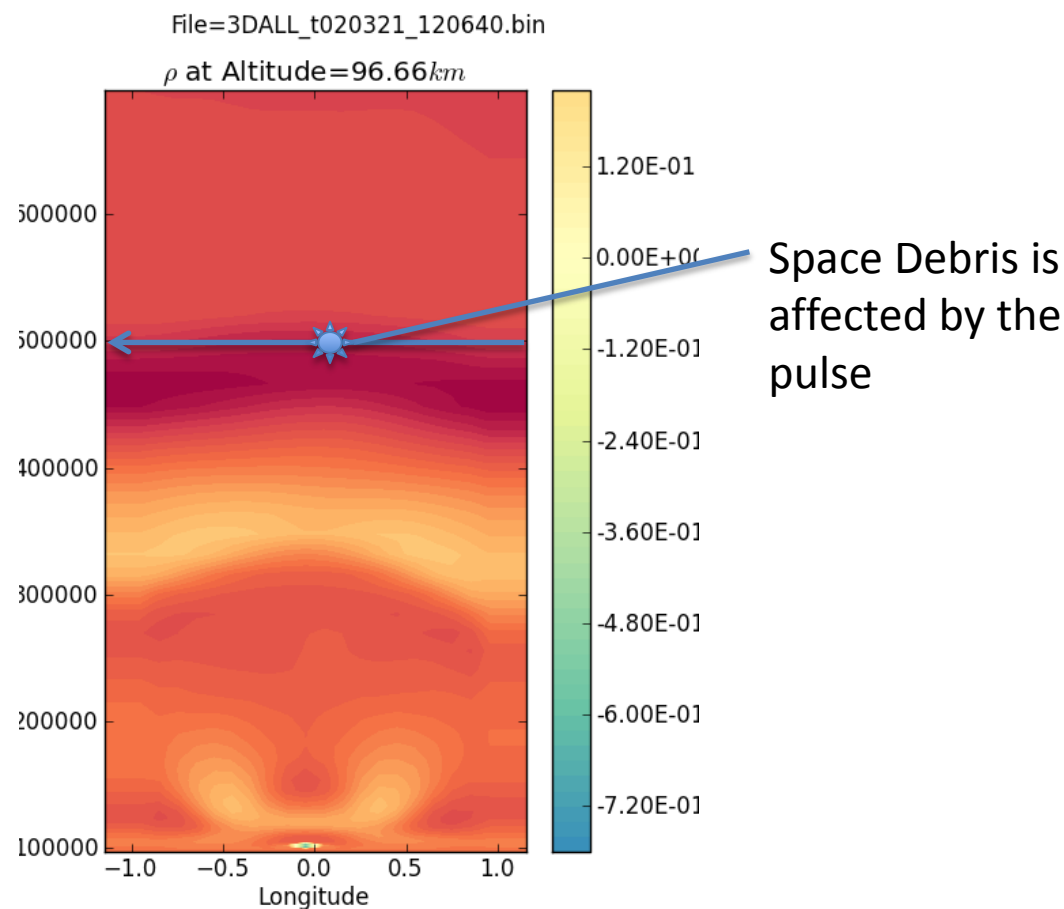
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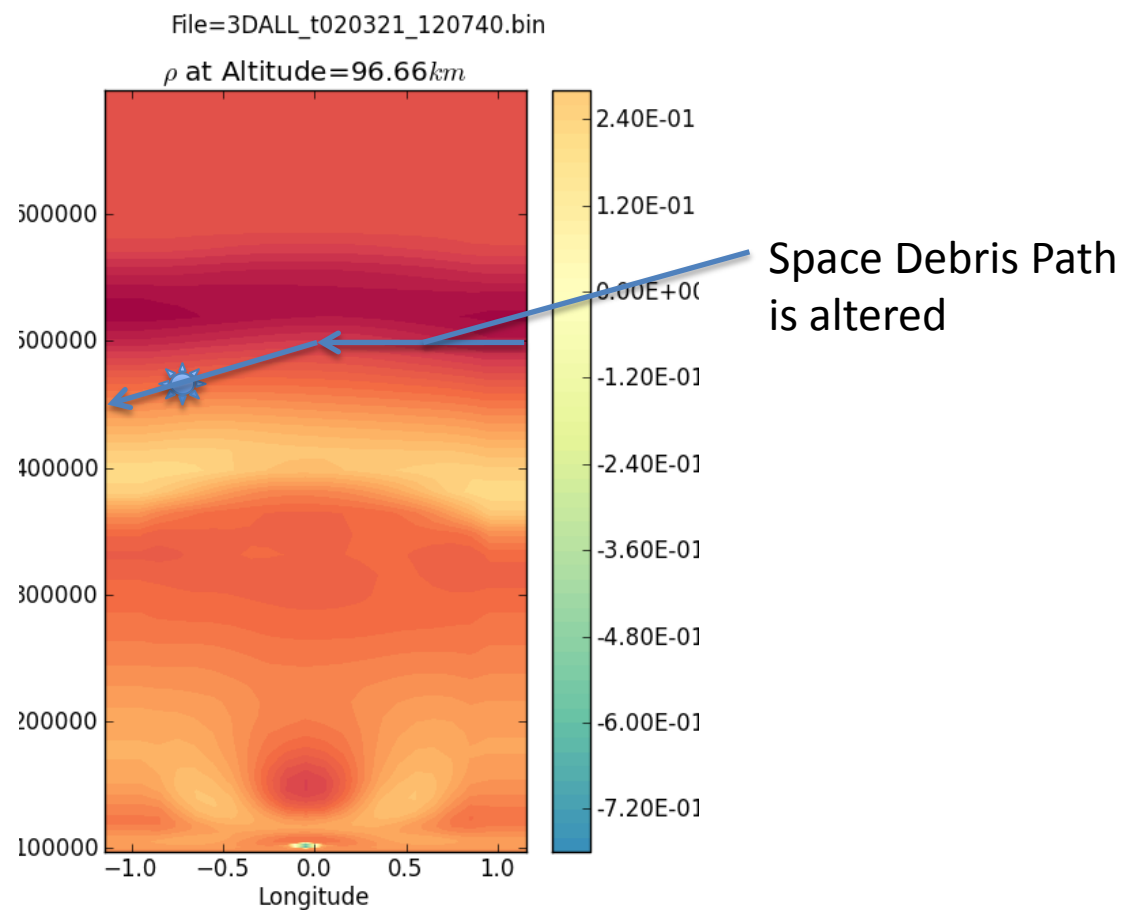
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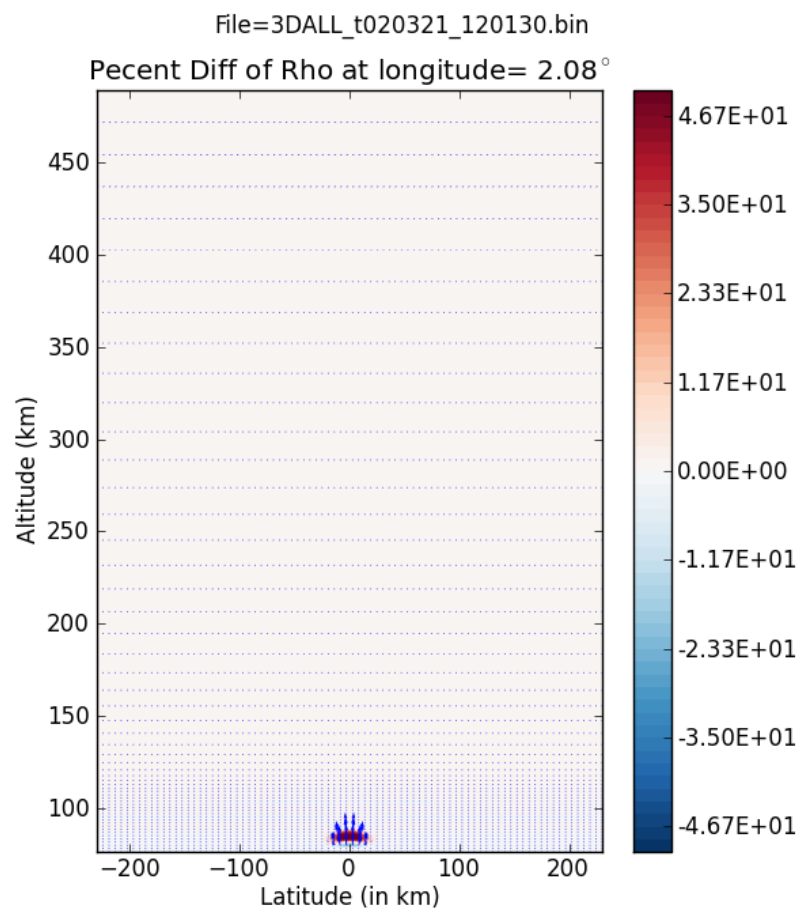


Perturbation Run 1

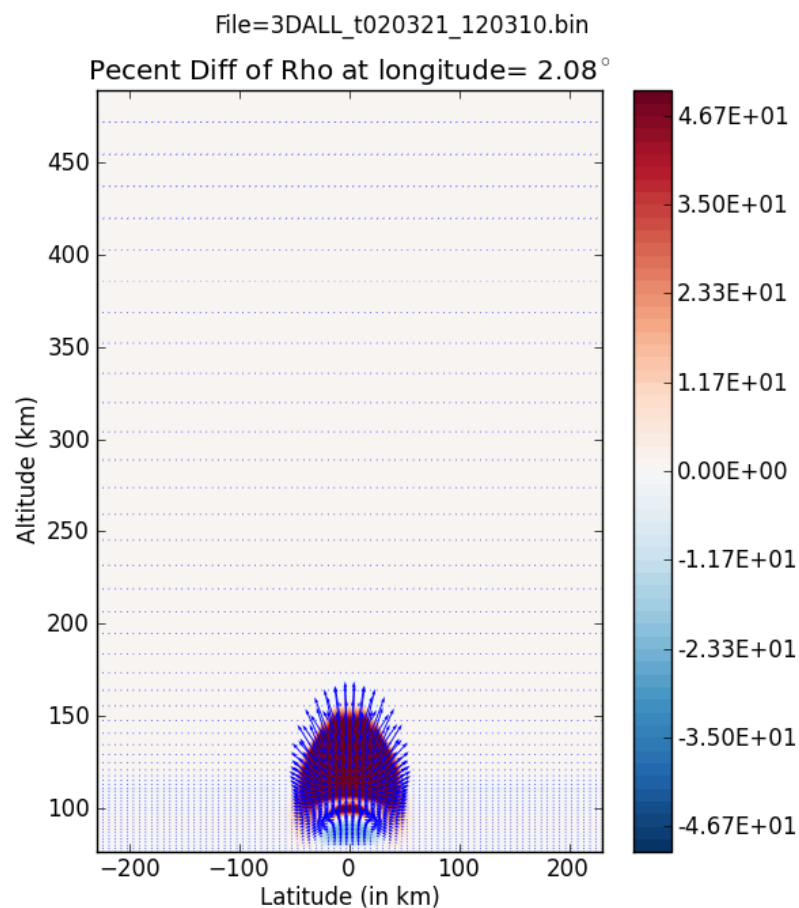
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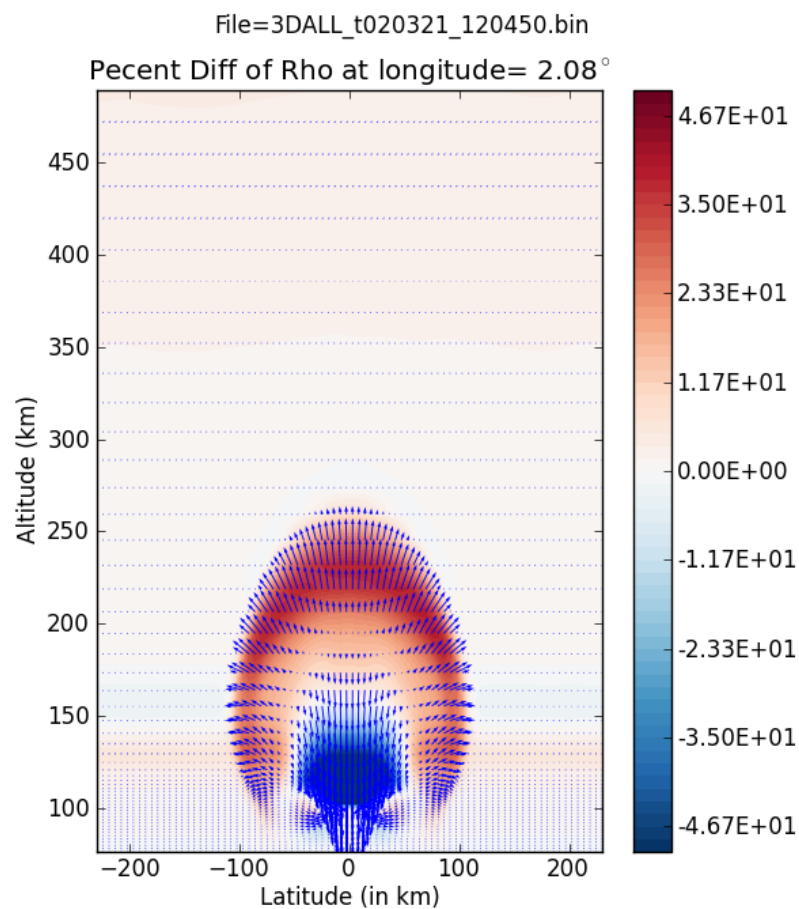
Perturbation Run 2



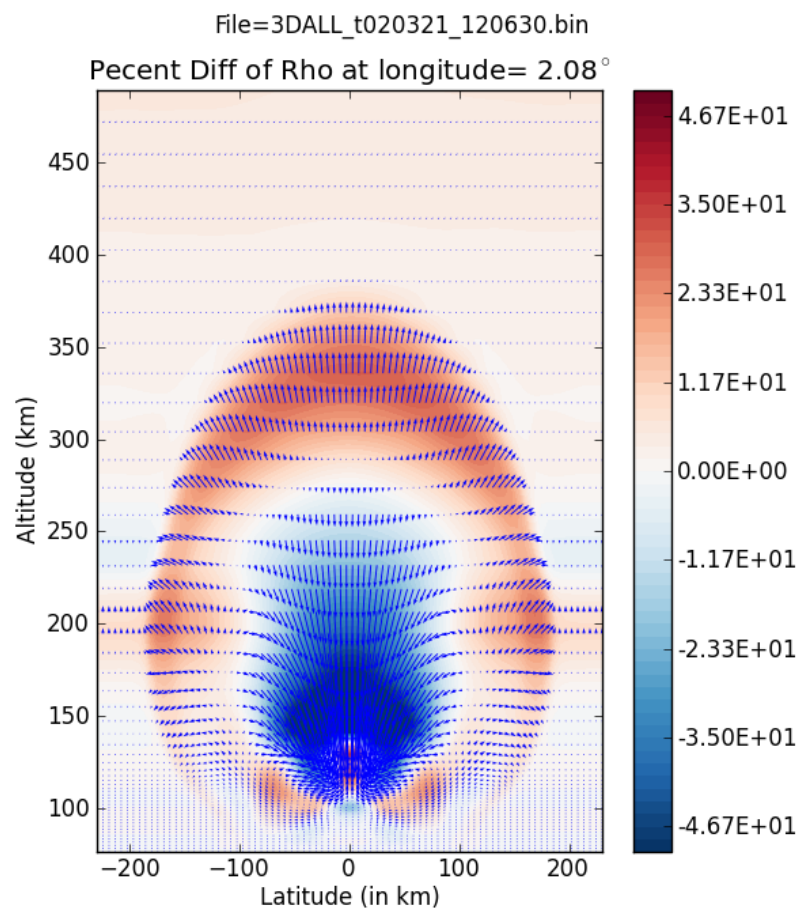
Perturbation Run 2



Perturbation Run 2

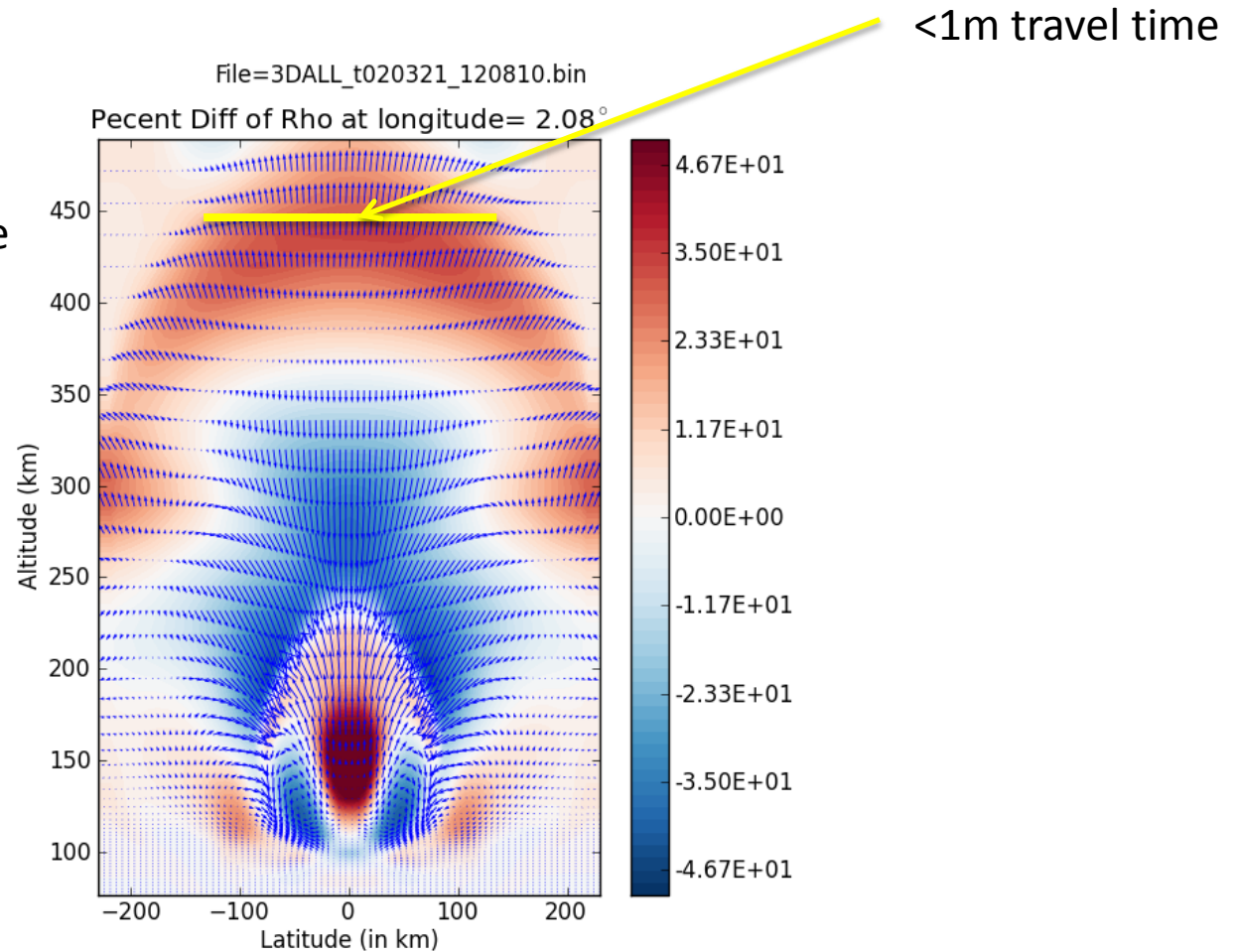


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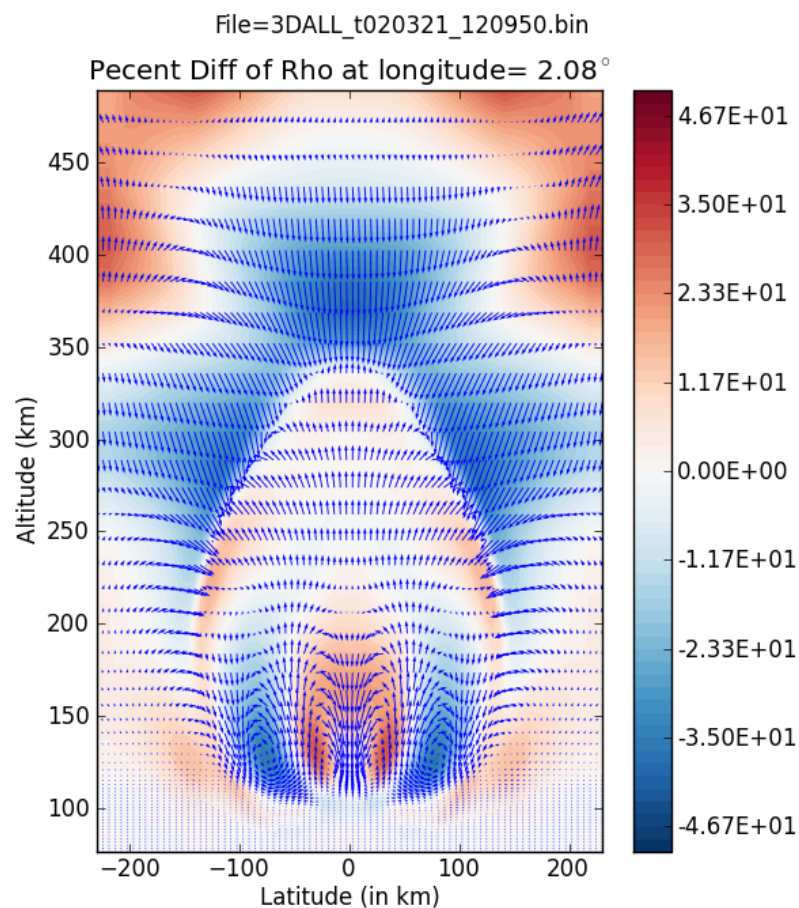


Perturbation Run 2

Over 20% rho difference
at 450 km

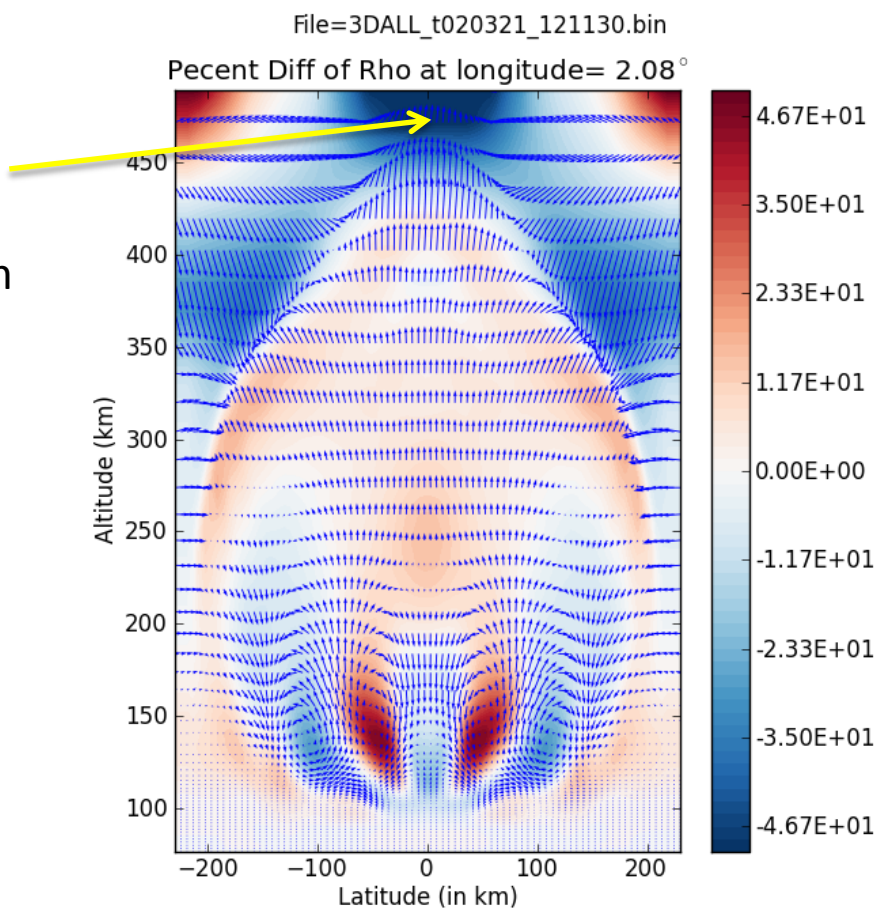


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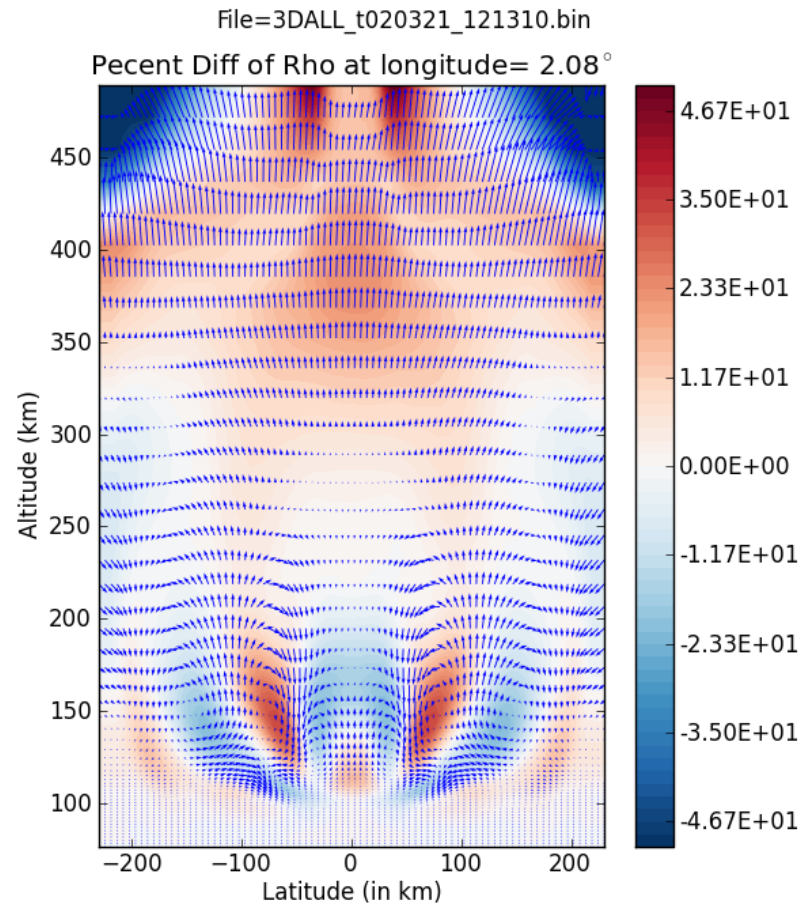


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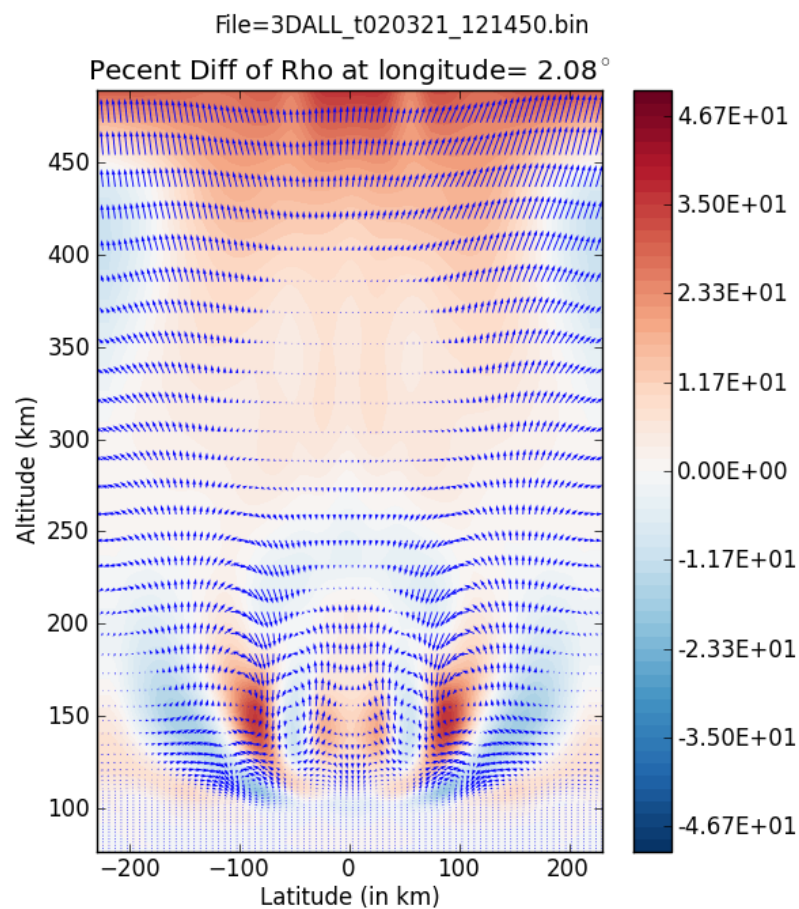
Unrealistic wave
reflection
can be mitigated with
higher boundaries



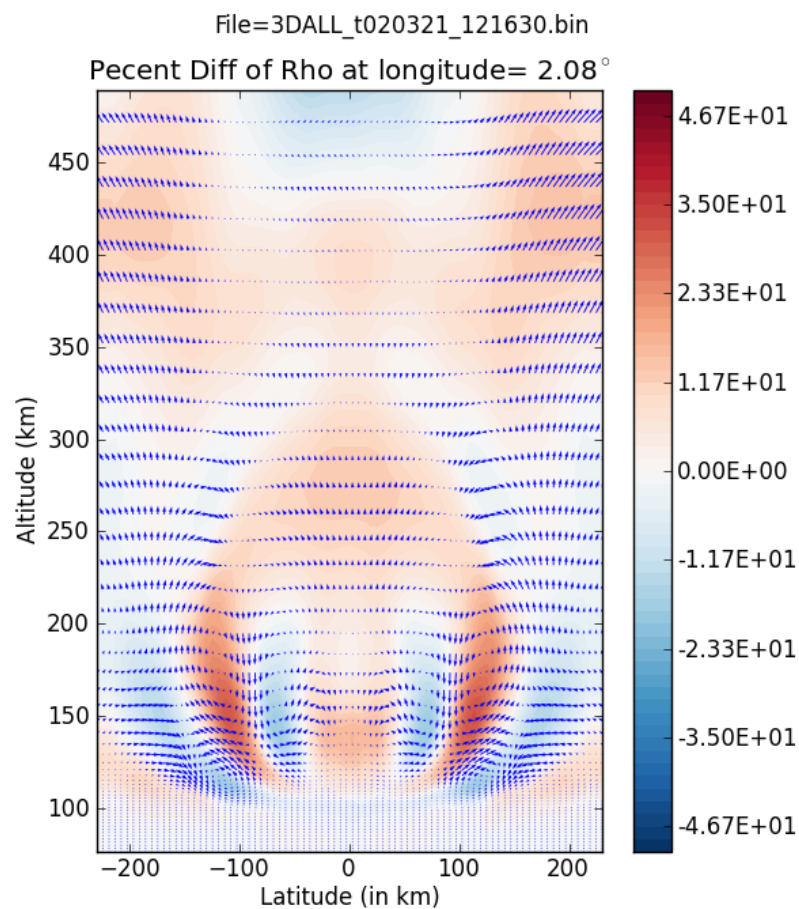
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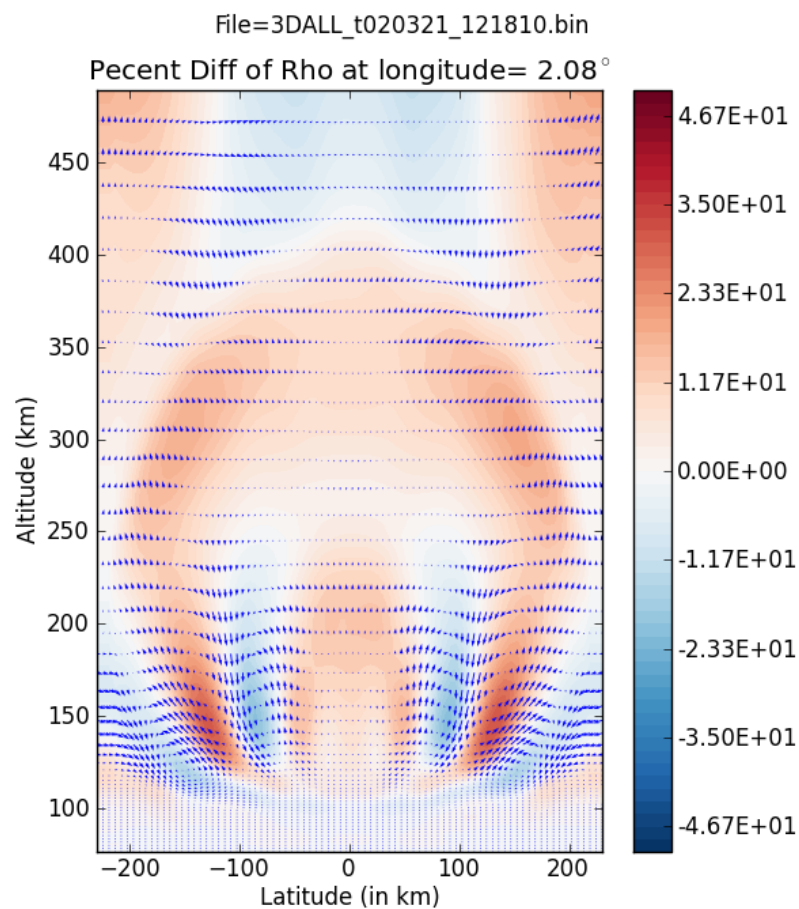
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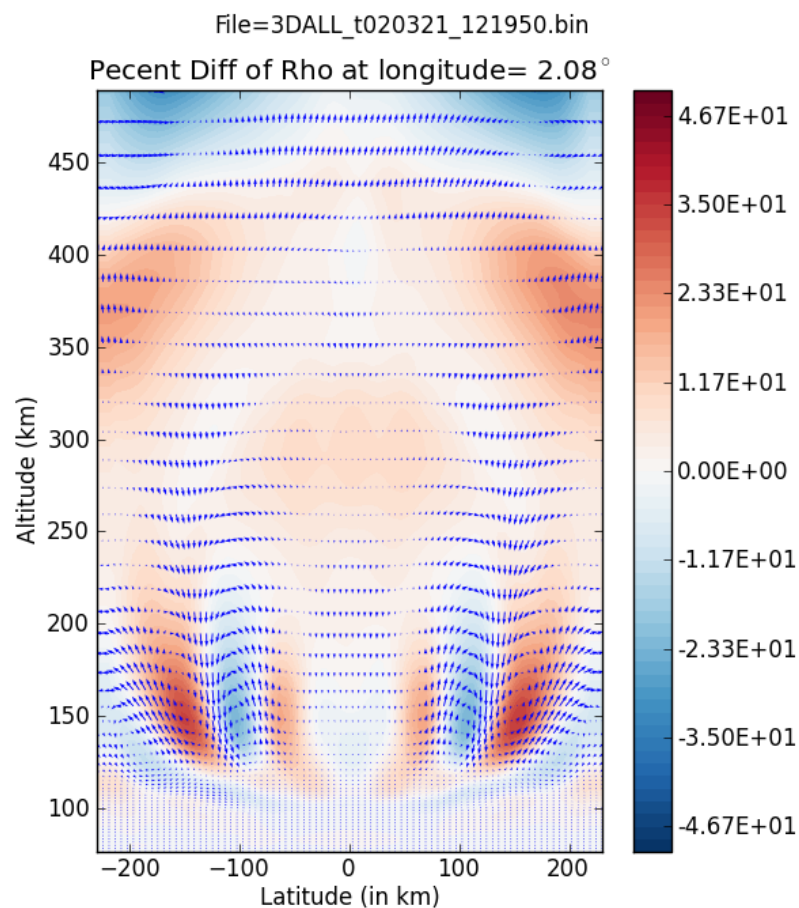
Perturbation Run 2



Perturbation Run 2



Perturbation Run 2



Intermediate Conclusion

- Preliminary analyses indicate that SpaDE is a viable solution in LOE debris removal

Further Studies

- Further analyses will address:
 - Further reduce lower bound to 30km
 - Difficult because Ozone absorption of solar energy is main energy source, which GITM doesn't consider. Working on a solution.
 - Add more realistic energy pulse to model simulations
 - Simulation Runs
 - Calculate the effects of pulse on the debris
 - Vary the perturbation of velocity, temperature, and pressure to determine the effectiveness of the solution
 - Determine the differences between energy pulses vs perturbations
- Additional Studies will address the key research topics focusing on economical, effective, and useful aspects of SpaDE

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QUESTIONS?